Design And As-Built Geotechnical Report For Emergency Stabilization

5700 Block Desert View Drive Alley, La Jolla, California

Prepared for | **October 14, 2010**

City of San Diego | **Volume 2 of 4**

Helenschmidt Geotechnical, Inc.

DESIGN AND AS-BUILT GEOTECHNICAL REPORTS
FOR EMERGENCY STABILIZATION
5700 Block of Desert View Drive Alley
La Jolla, California

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DESIGN GEOTECHNICAL REPORT
FOR EMERGENCY STABILIZATION
5700 Block of Desert View Drive Alley
La Jolla, California

1.0 INTRODUCTION

1.1 Report Outline

The following volume presents details of the subsurface investigation of landsliding and the design basis for the Desert View Alley stabilization measures. In order to expedite emergency stabilization measures for Desert View Drive Alley, a decision was made with City of San Diego officials to issue repair plans prior to providing a report with the basis for design for the Desert View Drive Alley repair, and to proceed with construction as soon as possible. Thus, this volume of the as-built report is presented in two parts. Part 1 of Volume 2 addresses geotechnical design for the repair of Desert View Drive Alley while Part 2 of Volume 2, is the as-built geotechnical report for the Desert View Drive Alley stabilization.

Subsurface conditions depicted on geologic cross sections previously issued in our report entitled ***Geotechnical Design Report for Shear Pin Landslide Stabilization of Soledad Mountain Road Right of Way, 5700 Block Soledad Mountain Road, La Jolla, California***, (Two Volumes), dated March 13, 2008 were modified based on exposures mapped during the repair of Soledad Mountain Road. The "As-Built" conditions are depicted on the sections issued in this report (Plates 2 and 3, Volume 4) and have superseded the prior geologic cross sections issued in previous reports by Helenschmidt Geotechnical, Inc. (HGI). The cross sections originally used for design, which were included in the design plans for the Desert View Alley stabilization are included with calculations in Appendix K (Volume 3).

1.2 Project Summary

The intent of the stabilization design presented herein is to increase the stability of the remaining landslide mass east of the completed improvements in the Soledad Mountain Road Right-of-Way, to an acceptable level consistent with the City of San Diego Abatement Order. The design is <u>not</u> directed at stabilization of private properties for current or future habitation. Assessment of the stability of private properties and mitigation measures, if required, are within the purview of the private property owners' geotechnical and structural consultants. The approximate location of the site is shown on the Site Location Map (Figure 1) and the As-Built Site Geologic Map (Plate 1, Volume 4).

The study area generally encompasses the section of Desert View Drive Alley between addresses 5720 to 5748 Desert View Drive. Additional subsurface investigation and geotechnical observation has been performed on the perimeter of the landslide which catastrophically failed on October 3, 2007 and on the private properties at 5695 to 5725 Soledad Mountain Road and 5734 Desert View Drive. Access to the lower portion of the landslide by large drilling equipment was precluded by the steepness of the post-failure ground surface during early stages of investigation. Acquisition of supplemental data regarding depth and inclination of the basal rupture surface of the October 3, 2007 landslide and the deeper ancient landslide was accomplished once safe access was established in the toe area of the slide.

The Desert View Drive Alley stabilization includes cast-in-drilled hole (CIDH) rebar reinforced concrete shear pins installed along a pre-existing general utility easement (the easement was widened to accommodate shear pins), installation of a reinforced earth compacted fill slope immediately adjacent to the west side of the Alley, regrading of the upper portion of the slope to a 3:1 (horizontal to vertical) inclination and surface and subsurface drainage improvements.

It is recognized that this portion of Soledad Mountain is characterized by geologically complex terrain and that identification of all potential threats is not possible through limited study for a particular area. Accordingly, our geotechnical study focuses on the recent landslide itself and has been directed primarily at identifying immediate risk to the public, developing recommendations to remediate landslide distress at Soledad Mountain Road and Desert View Drive Alley and to reduce risk of continued landslide movement in the two right-of-ways to acceptable levels. The following discussion of geologic and geotechnical features is based upon information acquired prior to the start of construction. Additional as-built data, which includes information collected during the implementation of the repair recommendations presented herein, are presented in Part 2 of this Volume of the report.

Desert View Drive is separated into two parallel streets. Lower Desert View Drive (or odd numbered addresses) is a through street, located east of Desert View Drive Alley (even numbered addresses), which is a long narrow cul-de-sac terminating at the south end. To avoid confusion, discussions in the following report will use Desert View Drive to refer to the lower through street and Desert View Drive Alley to refer to the cul-de-sac.

2.0 SCOPE OF SERVICES

The City of San Diego retained the services of HGI prior to the October 3, 2007 landslide in order to provide geotechnical design services for stabilization of the Soledad Mountain Road Right-of-Way in the vicinity of 5695 to 5725 Soledad Mountain Road. As a result of the catastrophic failure on October 3, 2007, our scope of services has been modified based on direction from the City of San Diego and has included the following:

- **Aerial Photograph Review** – Pre-development stereo-pairs of aerial photographs have been reviewed to evaluate topographic features at the site to identify the presence of ancient landslide features. Aerial photographs reviewed are referenced in Appendix A (Volume 3) of this report.

- **Review of Existing Geotechnical Reports and Geologic Data** – HGI reviewed predevelopment and as-graded reports for the Soledad Corona Estates subdivision. HGI also reviewed the City of San Diego Seismic Safety Maps and available published geologic maps for the area. Reviewed reports and data are referenced in Appendix A (Volume 3). HGI also reviewed relevant geotechnical data pertaining to the 1961 landslide immediately south of the recent landslide and a prior landslide stabilization project performed by the City of San Diego at the south end of Desert View Drive near the subject site.

- **Field Mapping** – Landslide distress features and exposed geologic features have been plotted on a topographic base map. The base map consists of a topographic survey of the landslide area and immediate adjacent areas performed by the City of San Diego Survey Department. The topographic map was utilized for: slope stability analysis; as a base map for presentation of exploratory boring and trench layout, and presentation of site geology; and as a base map for shear pin layout and grading operations.

- **Subsurface Exploration** – Subsurface exploration was performed with large and small diameter truck mounted rigs, limited access drill rigs, and a small excavator. Borings and trenches were logged by our field representatives who collected bulk and undisturbed samples for laboratory testing. Large diameter borings were downhole logged by our field representatives. Inclinometer casings were installed in several small diameter borings to provide data regarding the depth, magnitude and direction of landslide movement. Details of subsurface investigation are described later in this report.

- **Laboratory Testing** – Laboratory tests included maximum dry density, in-place moisture and moisture density, grain size analysis, direct and residual shear testing, consolidation, Atterberg Limits and chemical properties.

- **Inclinometer Monitoring** – HGI performed monitoring of inclinometer casings installed within and adjacent to the recent landslide.

- **Communications with the City of San Diego** – HGI coordinated with the City of San Diego and modified our scope of services according to project needs.

- **Geotechnical Analysis** – HGI evaluated the current slope stability and back-calculated landslide rupture surface strength parameters.

- **Report and Plans** – HGI prepared this technical report which includes a summary of geologic and geotechnical data to date regarding the recent landslide and the design basis for shear pin installation and slope reconstruction on the west side of Desert View Drive Alley in the area impacted by the October 3, 2007 landslide.

3.0 BACKGROUND

Refer to ***Geotechnical Design Report for Shear Pin Landslide Stabilization of Soledad Mountain Road Right of Way, 5700 Block Soledad Mountain Road, La Jolla, California***, (Two Volumes), dated March 13, 2008, by Helenschmidt Geotechnical, Inc., for a description of: historical site grading, distress features and progression of landslide failure, field exploration and laboratory testing, geologic conditions and slope monitoring.

4.0 STABILITY ANALYSIS

Our stability analysis was performed utilizing the XSTABL and STABL computer programs. XSTABL is a version of the STABL computer program developed at Purdue University. The analyses included consideration of failure along the well developed sheared clay seam that defines the base of the active landslide and a slightly deeper shear surface which is interpreted as an ancient landslide slip surface. These two surfaces are depicted on the design geologic cross sections (Appendix K, Volume 3) and the as-built geologic cross sections (Plates 2 and 3, Volume 4). Design factors of safety were calculated using a Spencer's analysis which satisfies all conditions of equilibrium.

In slope stability analyses, the factor of safety is defined as the ratio of the resisting forces to slope movement to the driving forces for slope movement. When this ratio (factor of safety) is 1.0 the driving and resisting forces are equal, indicating a high potential for slope movement. A factor of safety of greater than 1.0 would indicate that the slope is not moving.

4.1 Back Calculation of Strength Parameters

Rupture surface parameters (for the active landslide) were back-calculated using the configuration of the active landslide as delineated on the geologic cross sections developed during our investigation assuming a factor of safety of 1.0. Cross sections utilized for stability analyses are shown in Appendix K (Volume 3). Strength parameters of phi = 25 degrees and c = 200 psf were utilized in the analysis to represent landslide debris strengths with a lower (anisotropic) strength of phi = 20 degrees and c = 0 psf in the range of 55 to 60 degrees from horizontal. Groundwater was not included in the back-calculations. In addition, a cohesion of c = 0 psf was used for the basal rupture surface.

Our analysis incorporated back-calculation of geologic cross sections HGI-1 – HGI-1', HGI-4 – HGI-4' and HGI-5 – HGI-5'. These cross sections were selected based on the amount of reliable subsurface data acquired during investigation. Cross section HGI-6 – HGI-6' was not considered, at the time of investigation, to have the same level of reliable subsurface data as other sections and was therefore not included in our back-calculation analyses. Earlier back-calculations yielded a friction angle of 10.5 degrees for the basal rupture surface depicted on cross section HGI-1 – HGI-1', Plate 2 of ***Preliminary Report of Geotechnical Features Soledad Mountain Road Landslide, 5700 Block Soledad Mountain Road, La Jolla, California***, dated December 28, 2007, by Helenschmidt Geotechnical, Inc. Based upon subsurface data which was subsequently acquired in the toe area of the landslide, we revised the back-calculated rupture strength to the most conservative value obtained, 9.7 degrees. This friction angle is somewhat higher than laboratory residual shear test results which yielded a friction angle of approximately 7.5 degrees (zero cohesion). The following table presents a summary of the results of landslide rupture surface back-calculated strength parameters.

Table 1
Results of Back-Calculation
Stability Analyses

File Name	Method of Analysis	Factor Of Safety	Description
SMH1BC	Simplified Janbu	1.012	Back calculation of rupture surface parameters at cross section HGI-1 – HGI-1' using pre- October 3, 2007 topography. Assumes slide debris parameters of phi = 25 degrees and c = 200 psf (high angle anisotropic strength of phi = 20 degrees and c = 0 psf). Most critical surface determined using "block" analysis. Rupture surface strength of phi = 10 degrees and c = 0 psf.
SMH1BCS	Spencer	1.003	Analysis of most critical failure surface (derived from Janbu "block" search) on cross section HGI-1 – HGI-1'. Same landslide debris strength assumptions. Rupture surface strength of phi = 10 degrees and c = 0 psf.
SM4BC1A	Simplified Janbu	1.013	Back calculation of rupture surface parameters at cross section HGI-4 – HGI-4' using pre- October 3, 2007 topography. Assumes slide debris parameters of phi = 25 degrees and c = 200 psf (high angle anisotropic strength of phi = 20 degrees and c = 0 psf). Most critical surface determined using "block" analysis. Rupture surface strength of phi = 9.7 degrees and c = 0 psf.
SM4BC1AS	Spencer	0.995	Analysis of most critical failure surface (derived from Janbu "block" search) on cross section HGI-4 – HGI-4'. Same landslide debris strength assumptions. Rupture surface strength of phi = 9.7 degrees and c = 0 psf.
SM5BC1	Simplified Janbu	1.006	Back calculation of rupture surface parameters at cross section HGI-5 – HGI-5' using pre- October 3, 2007 topography. Assumes slide debris parameters of phi = 25 degrees and c = 200 psf (high angle anisotropic strength of phi = 20 degrees and c = 0 psf. Most critical surface determined using "block" analysis. Rupture surface strength of phi = 9.8 degrees and c = 0 psf.
SM5BC1S	Spencer	1.004	Analysis of most critical failure surface (derived from Janbu "block" search) on cross section HGI-5 – HGI-5'. Same landslide debris strength assumptions. Rupture surface strength of phi = 9.7 degrees and c = 0 psf.

4.2 Strength Parameters

The following strength parameters have been utilized in our analysis based on the results of laboratory testing, back-calculation and our experience with similar materials.

Table 2
Design Strength Parameters

Soil Type	Moist Unit Weight (pcf)	Cohesion (psf)	Friction Angle (degrees)
Rupture Surface (lowest back-calculated)	125	0	9.7
Landslide Debris	125	200	25
Landslide Debris (high angle shear)	125	0	20
Compacted Fill (existing)	125	200	25
Compacted Fill (existing)	125	250	25

4.3 Shear Pin Design Analysis

Shear pins were positioned within a pre-existing general utility easement at the east side of properties located at 5695 to 5725 Soledad Mountain Road. Shear pins were designed with a "Limit Equilibrium Analysis" assuming a target factor of safety of 1.5, and the strength parameters summarized above.. Multiple trial failure surfaces were generated along the basal rupture surface of the October 3, 2007 landslide and the underlying deeper ancient landslide between the toe of the slope and the East Side Shoring shear pins in the Soledad Mountain Right-of-Way. Resultant horizontal forces necessary for a factor of safety of 1.5 were determined and subsequently used for determination of CIDH shear pin embedment and structural design. Pier diameter and spacing, as well as embedment lengths were determined by consideration of resultant force magnitude and achievable construction details.

The final slope configuration assumed in the analysis included an approximate 1.5:1 (horizontal to vertical) slope above the Desert View Drive Alley shear pins. This is steeper than the proposed finish slope gradient (above the shear pins) of 3:1 (horizontal to vertical). This steeper inclination was considered in order to allow future slope construction on private lots (by individual property owners) of up to 1.5:1 (horizontal to vertical) on the upslope properties. Note that such slope reconstruction will require detailed independent geotechnical analysis and will also likely require recompaction of landslide debris, consideration of potential planes of weakness, soil reinforcement and potential settlement. This work would be under the purview of the property owners' geotechnical consultant and subject to the review and approval of the City of San Diego.

Ultimately, 72-inch diameter CIDH shear pins, either 72 or 80 feet in length were selected for stabilization. A total of 44 shear pins were proposed for the Desert View Alley stabilization with Shear Pins 77 through 95 consisting of a double row, due to high lateral resultant forces. Seismic design of shear pins was not included in our analysis. A concrete 28-day design compressive strength of 6000 psi was specified in the design plans as well as steel reinforcement consisting of 30, number 18 rebars. The following table summarizes required resisting forces on shear pins for each of the cross sections analyzed.

Table 3
Required Shear Pin Forces

Cross Section	Required Force (kips/ft)	Shear Pin Spacing (ft)	Resultant Horizontal Force (kips)
HGI 5-5'	95	6	570
HGI 1-1'	65	9	585
HGI 4-4'	65	9	585

Shear pins have been designed to act as a wall (above the basal rupture surface of the landslide). Transfer of soil lateral loads to the shear pin wall will be achieved by arching between the closely spaced shear pins. Shear pin design calculations are provided in Appendix L (Volume 3).

4.4 Lower Fill Slope Stability

A portion of the proposed stabilization included construction of fill slopes steeper than 2:1 (horizontal to vertical), which typically require reinforcement or other retaining measures to achieve an adequate factor of safety. Geogrid is a synthetic reinforcement material that is placed in compacted soil to add tensile strength to the soil. Geogrid enables fill soils to stand at steeper slope angles than would be possible without reinforcement. The soil reinforcement interlocks with the compacted soil and provides resistance to pullout initiated by failures near the face of slope. The lower portion of the Desert View Drive Alley slope was proposed at an approximate inclination of 1.5:1 (horizontal to vertical) slope or steeper. Installation of geogrid at relatively close vertical intervals was proposed to minimize the effects of surficial slope failures and to allow plant establishment while reducing raveling.

Due to chemical properties of the on site Ardath Shale derived soils, a polypropylene geogrid was selected rather than a polyester geogrid. Tensar BX 1200 (or approved equivalent) was specified at 1.5-foot vertical intervals with a minimum embedment length of ten feet measured from the slope face.

Stability analyses using the Spencer method (SlopeW program) was performed for a 1.5:1 (horizontal to vertical) slope with a height of 30 feet using the compacted fill parameters in Table 2. Stability calculations are provided in Appendix K (Volume 3). Since shear pins intersect the slope at the transition to the upper 3:1 (horizontal to vertical) slope, searches for critical deep failures did not include the upper 3:1 slope as a failure entry point. For deep-seated analysis, the most critical failure is outside the geogrid limits yielding a factor of safety of 1.52.

For surficial stability analysis, a three-foot depth of saturation was assumed with a failure surface parallel to the slope surface and of sufficient lengths to make entry and exit effects negligible. For surficial analysis, a factor safety of 3.69 was obtained for the geogrid-reinforced slope.

5.0 DISCUSSION AND CONCLUSIONS

The Mount Soledad area is known for unstable slope conditions caused by ancient landslides that were unrecognized during early developments in the 1950's and 1960's and by sheared bedding planes with out-of-slope dip components caused by tectonic folding and uplifting. The recent landslide is considered a reactivation of an ancient landslide that is identifiable in pre-development aerial photographs. The failure is interpreted to be block-glide on all or part of a pre-existing ancient landslide rupture surface. The landslide is similar in character to a previous block-glide landslide that occurred immediately to the south in 1961.

Grading was performed on the properties within the recent landslide limits in at least two episodes circa 1961 and 1967. Grading of the subdivision (in 1961) resulted in removal of materials at both the head and toe of the aforementioned ancient landslide. The grading did not include extensive stabilization such as construction of an earth buttress. Although flattening of the descending slope from the head of the landslide (Soledad Mountain Road) to the toe of the landslide (Desert View Drive Alley) occurred around 1967, the resulting configuration did not result in a significantly more stable condition.

The catastrophic failure that occurred on October 3, 2007 was the end result of a progressive failure that was evidenced by displacement along the northern margin of the landslide within Soledad Mountain Road starting at least as far back as March 2007. Although not originally attributed to landsliding, distress features described in an August 14, 2007 geotechnical report suggest that landslide distress at 5725 Soledad Mountain Road may have been occurring at least 3 1/2 years prior to the catastrophic failure.

The proposed shear pin stabilization was selected based on feasibility of construction and the desire to minimize encroachment of permanent repair features on private properties. The CIDH shear pin design provides a minimum factor of safety of at least 1.5 under static conditions relative to the Desert View Drive Alley Right-of-Way. Design recommendations for shear pins were incorporated into the plans entitled ***Construction and Grading Plans For: Desert View Drive Alley Emergency Repair*** (20 sheets plus three delta plan changes comprising four additional sheets; total 24 sheets), dated October 20, 2008, prepared by Helenschmidt Geotechnical, Inc. An as-built set of the repair plans has been included in Appendix C (Volume 3) of this report.

6.0 SUMMARY OF RECOMMENDATIONS

The repair plans entitled ***Construction and Grading Plans For: Desert View Drive Alley Emergency Repair*** (20 sheets plus three delta plan changes comprising four additional sheets; total 24 sheets), dated October 20, 2008, prepared by Helenschmidt Geotechnical, Inc. provide details for the construction of the Desert View Drive Alley stabilization. The following provides a brief summary of recommendations that were incorporated into the design plans. The proposed construction included establishing of construction access for drilling of shear pins, construction of a crane pad, sequenced construction of CIDH shear pins, excavation of the Desert View Drive keyway, slope reconstruction, installation of surface drainage features and repaving of Desert View Drive Alley between Palomino Circle and the southern edge of the construction zone.

6.1 Construction Access and Drilling

Limited construction access to the landslide toe area was possible across the temporary gravity buttress that was placed following reactivation of the landslide mass in January, 2008. However, the toe of the landslide required reconfiguration to allow access for drilling and heavy lifting equipment to construct the shear pins (as outlined below). Grading for access to the toe area was proposed in accordance with the Phase 1: Construction Access Plan (see sheet 31 of 50, Appendix C, Volume 3). The grades shown were designed to minimize removal of material from the toe of the landslide that could result in destabilization of the remaining landslide mass, and to accommodate the heavy lifting equipment required to pick up prefabricated rebar cages from Desert View Drive and lift and place them into the proposed shear pin locations.

As was required for the construction of Soledad Mountain Road shear pins, it was recommended that the contractor drill every third shear pin boring, complete shear pin construction and demonstrate at least 80 percent of the concrete design compressive strength has been reached prior to proceeding with the subsequent group of every third shear pin boring. Selected shear pin borings were recommended to be down hole inspected by a representative of HGI to confirm embedment into suitable bedrock soils.

6.2 Crane Pad

As part of Phase 1: Construction Access Plan (see sheet 31 of 50, Appendix C, Volume 3), a fill pad was designed to accommodate a crane. The pad consisted of geogrid-reinforced Caltrans Class II aggregate base compacted to 95% relative compaction (ASTM D-1557) surrounded by k-rail on the north, east and south sides. Crane outriggers were to be supported on a poured in place mat foundation on the east side and double stacked, eight-foot steel trench plates on the west side, as detailed on sheet 32 of the as-built project plans (Appendix C, Volume 3).

6.3 Shear Pin Construction

Shear pins were to be constructed in sequence with the center section first followed by the end sections. The center section was required to be completed to allow a temporary 0.75:1 (horizontal to vertical) cut to be constructed for crane access closer to the toe of slope on Desert View Drive Alley. In order to facilitate drilling and construction of the remaining CIDH shear pins, the drilling platform was to be expanded at the north and south sides of the landslide toe. In order to avoid cuts into unstable landslide debris, temporary, geogrid reinforced fill slopes were proposed as shown on the Phase 2: Construction Access Plan and cross sections on sheets 16 through 19 of the as-built project plans (Appendix C, Volume 3). Fill soils placed for temporary drilling pads must be tested for compaction by a representative of HGI.

6.4 Keyway Construction

Grading for keyway construction in three individual slots was proposed following completion of Shear Pins 77 through 120. Grading for slot cut construction is shown on pages 24 and 25 of the as-built project plans (Appendix C, Volume 3). Excavation bottoms were to be documented and approved by a representative of HGI, and the required section of the subdrain installed before fill placement.

6.5 Geogrid Reinforcement and Slope Reconstruction

Geogrid reinforcement, consisting of Tensar BX 1200.4 or approved equivalent, on 1.5-foot vertical centers was recommended (with survey control) for the lower slope below the shear pins. Fill compaction was specified as 90% minimum compaction based on ASTM D-1557.

The upper 3:1 (horizontal to vertical) slope, above the shear pins, was recommended to be compacted near the surface to 90% relative compaction as was the fill placed to bring the residential property pad areas even with Soledad Mountain Road. A mid-slope key was recommended to address a weak clay seam found during mapping of the landslide slope area.

6.6 Subdrainage

A subdrain consisting of six-inch diameter, perforated Schedule 40 PVC pipe surrounded by 3/4-inch washed gravel and Mirafi 140N filter fabric was recommended along the Desert View Drive Alley keyway with a proposed outlet along the north side of 5734 Desert View Drive Alley. The outlet was to be drilled in the same manner as that installed in the Soledad Mountain Road keyway. The subdrain was proposed to be terminated into a D-25 Type A curb outlet at Desert View Drive. Recommendations were also provided to tie in the outlet pipe from the Soledad Mountain Road keyway to the D-32 headwall, which was constructed per sheet 22 of the as-built project plans (Appendix C, Volume 3).

6.7 Repaving

Repaving of Desert View Drive Alley, between Palomino Circle and the south limits of work on Desert View Drive Alley was to be completed in accordance with City of San Diego paving section requirements and the original roadway plans by Inter-City Engineers dated May 14, 1974. The upper 12 inches of subgrade was to be compacted to a minimum of 95% relative compaction (ASTM D-1557) and overlain by a design pavement section consisting of three inches of asphaltic concrete over nine inches of Caltrans Class II aggregate base. Surface drainage along Desert View Drive Alley should be restored to its original configuration to allow conveyance of surface water to storm drains on Desert View Drive.

6.8 Construction Observation and Monitoring

Grading and construction were to be performed under the observation and testing of HGI.

7.0 LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices. No warranty, express or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings.

VOLUME 2, PART 2

AS-BUILT GEOTECHNICAL REPORT
FOR EMERGENCY STABILIZATION
5700 Block of Desert View Drive Alley
La Jolla, California

1.0 INTRODUCTION

1.1 Report Outline

Part 2 of Volume 2, contained herein, details the construction activities and as-built conditions relating to the stabilization of Desert View Drive Alley Right-of-Way, which was buried by the toe of the landslide that occurred on October 3, 2007. Part 2 is the companion report to Part 1 Volume 2, which provides details of the design process for the stabilization repair, from which the design plans, ***Construction and Grading Plans For: Desert View Drive Alley Emergency Repair***, dated October 20, 2008, prepared by Helenschmidt Geotechnical, Inc., were derived. The initial set contained 20 sheets, providing construction details for shear pin construction, keyway excavation and slope reconstruction. Three delta plan changes were made during the course of construction, which added four sheets the construction plans. As-built project plans are presented in Appendix C (Volume 3) of this report.

1.2 Project Summary

The following report presents the results of our observation, testing and analysis during repair of the landslide that occurred in the 5700 Block of Desert View Drive Alley, La Jolla, California (Figure 1). The landslide occurred at approximately 8.50 am on October 3, 2007. The landslide involved a block-glide type failure approximately 250 feet in width, and represents a partial re-activation of a larger ancient landslide underlying the Soledad Corona Estates subdivision. Both the Soledad Mountain Road and Desert View Drive Alley Right-of-Ways were rendered impassable. Four single family residences were fully or partially destroyed during landsliding (5703, 5715 and 5725 Soledad Mountain Road and 5734 Desert View Drive Alley), while three other residences (5695 and 5735 Soledad Mountain Road and 5748 Desert View Drive Alley) sustained varying degrees of damage, but to date remain in place.

Mitigative measures were developed and implemented to address the local stability of the Soledad Mountain Road and Desert View Drive Alley Right-of-Ways with respect to the recent (October 3, 2007) landslide failure. Local stability for areas outside the limit of work as shown on Plate 6 (Volume 4) was not addressed as part of this project. This report summarizes construction activities and presents as-built conditions, based on grading and construction plans developed by Helenschmidt Geotechnical, Inc. (HGI). Construction activities were completed in multiple phases between October 2007 and June 2009. Construction and grading activities for Desert View Drive Alley, the focus of Part 2 of Volume 2 of this report, were performed between October 2008 and June 2009. The stabilization of Desert View Drive Alley included installation of 44 72-inch diameter shear pins along a pre-existing general utility easement along the east property lines of 5695 to 5725 Soledad Mountain Road, construction of a reinforced earth fill slope at the toe of the October 3, 2007 landslide, re-grading of the landslide, installation of drainage improvements and repaving of Desert View Drive Alley.

The as-built topographical survey map of the project site was produced by the City of San Diego Survey Department, and provided to HGI, was utilized as the base map for Plates 1, 5, 6 and 8 contained in Volume 4 of this report.

Our scope of work was limited to the stabilization of the portions of the City of San Diego Right-of-Ways affected by the October 3, 2007 landslide. Stability of private properties affected by recent landsliding was outside our scope of work and will require site specific geotechnical investigations, conclusions and recommendations, for future improvements or redevelopment.

2.0 SCOPE OF WORK

The following services were performed by HGI during and after grading and construction activities for the stabilization of the Desert View Drive Alley Right-of-Way:

- **Observation of Subsurface Conditions** – HGI observed the site soil conditions during drilling, excavation and grading to confirm subsurface conditions and soil properties interpolated from exploratory borings and test pits advanced as part of the preliminary subsurface investigations summarized in our reports entitled ***Preliminary Report of Geotechnical Features Soledad Mountain Road Landslide, 5700 Block Soledad Mountain Road, La Jolla, California***, dated December 28, 2007 and ***Geotechnical Design Report for Shear Pin Landslide Stabilization of Soledad Mountain Road Right of Way, 5700 Block Soledad Mountain Road, La Jolla, California***, (2 Volumes), dated March 13, 2008.

  Excavation monitoring was performed throughout this phase of the project to check that excavation limits conformed to those specified in the project plans, and that adequate embedment of the keyway bottom the landslide rupture surface was achieved. Cut slopes were mapped to document subsurface geologic conditions and to see that adversely dipping planes of weakness such as bedding plane shears, joint sets or faults were not present that would impact excavation safety and stability.

- **Downhole Logging of Shear Pin Borings** – Selected shear pin borings were downhole logged by a Certified Engineering Geologist, Registered Geotechnical Engineer or Professional Geologist to check the depth and inclination of the landslide rupture surface, to document other planes of weakness (if present) as well as salient geologic features and to confirm adequate shear pin embedment into firm soils.

- **Observation and Testing During Fill Placement** – Representatives of HGI documented the limits of removal and inspected and certified the keyway bottoms prior to placing fill or other improvements. Our representatives performed compaction testing during fill placement utilizing the Sand Cone Method (ASTM D-1556) or the Nuclear Densometer Method (ASTM D-2922), and monitored the installation of geogrid to check compliance with the project plans and manufacturer's specifications for proper installation. A summary of compaction test data is presented in Appendix F (Volume 3) with density test locations provided in Plate 6 (Volume 4).

- **Import Soils –** All imported fill soils were approved by HGI prior to hauling. Gradation specifications and maximum dry density were tested in our laboratory.

- **Laboratory Testing –** Laboratory testing was performed throughout the project to evaluate soil conditions and strength parameters for design purposes. Tests included maximum dry density, in-place moisture and moisture density, grain size analysis, direct and residual shear testing, consolidation, Atterberg Limits and chemical properties. Test results are summarized in Appendix M (Volume 3).

- **Review and Compilation of Test Results of Special Inspection of Concrete and Steel Reinforcement** – Results from special inspection of rebar reinforcement and concrete testing for CIDH shear pins were reviewed to check compliance with the project plans. Test results were compiled and are presented in Appendix G (Volume 3).

- **Construction Monitoring** – Construction monitoring, including monitoring of slope inclinometers, portable seismographs, crack gauges and survey monuments was performed throughout the project. Monitoring of slope inclinometers in certain areas is still ongoing.

  Inclinometers were installed within the October 3, 2007 landslide mass, as well as in adjacent areas, to enable monitoring of any subsurface movement, and to monitor temporary slopes during excavation and construction. Readings were performed weekly, or as-needed depending on construction activities. Post-construction monitoring of remaining inclinometers is ongoing and is performed on a monthly basis. Inclinometer installations are shown on Plate 7 (Volume 4) and results are presented in Appendix I (Volume 3).

  Monitoring of ground vibrations was performed throughout the course of project in order to see that construction related vibrations remained within tolerable limits with respect to adjacent residential structures. Portable seismographs were set up in a variety of locations on permanent or semi-permanent basis, depending on the specific location of construction activities on the site and the proximity to adjacent residential structures. Seismograph monitoring locations are shown on Plate 7 (Volume 4) and results are presented in Appendix H (Volume 3).

  Crack gauges were installed across exterior cracks on 5735 Soledad Mountain Road due to the proximity of the residence to the northern side scarp of the October 3, 2007 landslide. Gauges were monitored and photographed periodically for comparison with previous readings.

  A network of survey monuments was set up in and around the project site read by the City of San Diego Survey Department. Monitoring locations and frequency was determined by the City of San Diego. At the request of HGI, specific survey monuments and/or target reflectors were installed on residential structures in close proximity to the repair and read by the City of San Diego Survey Department as part of their monitoring program.

- **Geotechnical Consultation** – Geotechnical consultation, including attendance at weekly construction meetings was provided for the duration of construction.

- **As-Built Analyses** – Depths and orientations of the basal rupture surface of the October 3, 2007 landslide and the underlying landslide varied somewhat in the landslide toe area from those interpreted for design based on exposures during grading and downhole logging of shear pin borings. Consequently, additional stability analyses have been performed, based upon as-built conditions at the site, in order to compare to stability analyses performed for design purposes and to check that the desired factor of safety has been achieved. As-built slope stability analyses are presented in Appendix K (Volume 3) of this report.

- **As-Built Report** – The following report (Four Volumes), in addition to as-built plans for all phases of construction have been prepared which outline activities and the results of our observations, testing, and analyses.

3.0 SUMMARY OF GEOTECHNICAL INVESTIGATION AND ANALYSIS

At the request of the City of San Diego, HGI began a geotechnical investigation on October 2, 2007 to examine surface features that were developing within the 5700 Block of Soledad Mountain Road and Desert View Drive Alley. Following landsliding that occurred on the morning of October 3, 2007 which rendered Soledad Mountain Road and Desert View Drive Alley Right-of-Ways impassable, HGI modified the scope of work to develop a plan for repair and stabilization. Preliminary conclusions and recommendations were issued in a pair of reports entitled ***Preliminary Report of Geotechnical Features Soledad Mountain Road Landslide, 5700 Block Soledad Mountain Road, La Jolla, California,*** **dated December 28, 2007, and** ***Conceptual Repair Options for Soledad Mountain Road and Desert View Drive Alley, Soledad Mountain Road Landslide, La Jolla, California***, dated February 11, 2008. Several repair options were considered, including tie backs, shear pins, conventional earth buttresses and combinations thereof. However, in order to significantly reduce the potential for further lateral slope movement, and to provide increased slope stability during repair efforts with minimal encroachment onto private property, cast-in-drilled-hole (CIDH) rebar reinforced concrete shear pins were selected as the preferred repair design alternative.

Field exploration following landsliding included geologic mapping of surface features and exposures, drilling and logging of small and large diameter borings and excavation and mapping of backhoe trenches within and adjacent to the landslide mass. A series of inclinometers were installed to monitor any ongoing slope movement. Crack gauges were also installed across cracks on the exterior of certain adjacent residential structures to monitor any damage related to extension of side scarps.

As previously mentioned, our preliminary findings were published in the above referenced reports. Our understanding of the site geology was continually refined as the repair progressed, both from downhole logging of shear pin borings and advancement of additional small diameter borings for inclinometer installations. Following construction of temporary shoring, construction of the East Side Shoring and excavation and grading within the Soledad Mountain Road was performed pursuant to our recommendations in the report entitled ***Geotechnical Design Report for Shear Pin Landslide Stabilization of Soledad Mountain Road Right of Way***, (Two Volumes), dated March 13, 2008, and the project plans ***Grading Plans For: Soledad Mountain Road Emergency Repair, 5700 Block, Soledad Mountain Road***, dated May 19, 2008, prepared by Helenschmidt Geotechnical, Inc. During the course of stabilization efforts in Soledad Mountain Road, additional data was gathered regarding the geometry of the landslide failure plane, the presence or absence of additional bedding plane shears and the condition of bedrock materials below the landslide failure plane which was used to further refine our geologic model for the site. Based on this data, cross sections were revised for use in shear pin design and grading recommendations for the repair of the Desert View Drive Alley Right-of-Way. Cross sections have been subsequently updated or 'As-Built' based on data acquired during this construction phase and are presented as Plates 2 and 3 (Volume 4).

4.0 CONSTRUCTION ACTIVITIES, GEOTECHNICAL OBSERVATIONS AND TESTING

4.1 Overview

Reconstruction of the Desert View Drive Right-of-Way and the east facing slope between Soledad Mountain Road and Desert View Drive Alley was performed by Hazard Construction, Inc., during the period of October 2008 through June 2009. Anderson Drilling, Inc. and Marco Crane, Inc. were subcontracted by Hazard Construction, Inc. to construct the CIDH shear pins. HGI provided geotechnical observation and testing on a continuous basis during construction.

Slope stabilization and repair of the Desert View Drive Alley Right-of-Way included installation of 44, 72-inch diameter, CIDH rebar reinforced concrete shear pins, installed in two phases. The shear pins were numbered consecutively from 77 to 120, with a double row at the north end below 5725 and 5735 Soledad Mountain Road. The initial phase of shoring installation occurred across the central portion of the landslide mass, and included Shear Pins 94 through 110 and 85. The second phase included the remainder of the shear pins to the north and south, which could not be reached by the crane during the initial phase of installation. The minimum design strength for concrete used in Shear Pins 77 through 120 was 6000 psi. All concrete was placed by the tremie method and a concrete vibrator was used in the upper 10 feet. Data gathered during installation of shear pins, including construction dates, depths and elevations is tabulated in Appendix G (Volume 3). As-built locations are shown on Plate 1 and Plates 5 through 8 (Volume 4).

Following shear pin installation, landslide debris on, and to the west of Desert View Drive Right-of-Way was removed during a phased, three slot cut construction process, and replaced with compacted, engineered fill consisting of geogrid reinforced on site soils. Subsurface drainage was also installed to provide keyway drainage. Six-inch perforated, Schedule 40 PVC pipe surrounded 3/4- inch washed rock wrapped in filter fabric was tied into a solid, Schedule 40 PVC outlet pipe installed in a sub-horizontal boring along the specified alignment between 5734 and 5748 Desert View Drive Alley, discharging via a D-25 (Type A) curb outlet on Desert View Drive. Curb line and grade and finished road grades were restored to their pre-failure configuration from Palomino Circle to the southern limit of work on Desert View Drive Alley.

4.2 Project Plans

Recommendations for repair were incorporated into a series of design plans prepared by HGI. Table 1 below summarizes all issued plan sets and plan changes that were signed by the City of San Diego and used for construction.

Table 1
Summary of Construction Plan Sets

Set Number	Title of Construction Plan Set	Work Order Number	Date Signed by City of San Diego	Sheet Numbers
1	Construction Plans For: Soledad Mountain Road Emergency Repair (Temporary Shoring)	992019	11/1/07	34701-01-D to 34701-03-D
2	Construction Plans For: Soledad Mountain Road Emergency Repair (East Side Shoring)	992019	3/18/08	34701-01-D to 34701-03-D
3	Grading Plans For: Soledad Mountain Road Emergency Repair	992019	5/21/08	34701-01-D to 34701-11-D *Delta 1: Sheet 12 to Sheet 14 *Delta 2: Sheet 15 *Delta 3: Sheet 16
4	Construction and Grading Plans For: Desert View Drive Alley Emergency Repair	528051	10/20/08	34701-01-D to 34701-20-D *Delta 1: Sheet 21-22 *Delta 2: Sheet 23 *Delta 3: Sheet 24

*Additional sheets were added in the field to the plan set maintained by the City of San Diego Resident Engineer.

Reports, plans and delta revisions prepared by HGI for the project are also listed in Appendix A (Volume 3). As-built project plans have been compiled by HGI. Following discussions with the City of San Diego, it was decided that once redline changes were approved, the project mylars for each phase of the project would be combined into a single plan set that would also include utility restoration plans for Soledad Mountain Road (prepared by the City of San Diego). Consequently, a single mylar set of 50 sheets (renumbered sequentially) was delivered to the City of San Diego for final signatures on July 1, 2010, and a reduced copy of these plans has been provided in Appendix C of this report (Volume 3).

4.3 Construction Sequencing

The following is a detailed discussion of the sequence of construction events for the repair and reopening of the Desert View Drive Alley Right-of-Way:

4.3.1 Installation of Temporary Fire Lines – As a result of the October 3, 2007, the fire hydrant immediately west of 5720 Desert View Drive Alley was destroyed. Consequently, the San Diego Fire Department did not have a high pressure water supply that could be utilized to fight structure fires on the south end of Desert View Drive Alley. At their request, high pressure water lines constructed from six-inch ductile iron pipe with four-way inlet/outlet valves on each end were installed at two locations to provide fire line service. Orientation and layout of the temporary fire lines are shown on a plan sheet presented in Appendix D (Volume 3). Temporary fire lines were removed at the completion of grading and construction activities, following the installation of a replacement fire hydrant west of 5720 Desert View Drive Alley.

4.3.2 Installation of Shear Pins 94 through 110 and 85 (Phase I) – A series of 18, 72-inch diameter CIDH shear pins were installed west of Desert View Drive Alley in the locations shown on the As-built plans in Appendix C (Volume 3) and in Figure G-2 (Appendix G, Volume 3). In order to construct these shear pins, preliminary grading was performed in accordance with the Phase I: Construction Access Plan on page 31 of the as-built project plans (Appendix C, Volume 3). Grading included minor cuts and fills to facilitate moving of drilling and heavy lifting equipment, construction of a level drilling pad at elevation 440 feet (msl) and construction of a temporary crane platform at elevation 425 feet (msl) comprised of geogrid-reinforced Caltrans Class II aggregate base compacted to a minimum of 95% relative compaction (ASTM D-1557) with an associated reinforced concrete mat footing and trench plates for outrigger support. Geogrid reinforcement for the crane pad consisted of Mirafi Miragrid 24XT placed every 6 or 12 inches, depending on elevation (See Detail B, sheets 32 of 50, Appendix C, Volume 3). The initial layer was laid down with the uniaxial strength direction parallel to Desert View Drive Alley. Uniaxial strength direction was rotated in subsequent layers by 90 degrees to form an alternating pattern to provide improved support in all directions. Outrigger supports were positioned to allow both pick up and placement of reinforcement cages (fabricated off site) without repositioning the crane.

The shear pin alignment selected was approximately parallel to Desert View Drive Alley, and west of the City of San Diego maintained Right-of-Way. An existing general utility easement was used for shear pin installation but required expansion to encompass the footprint of the shear pins. Shear pins 85, 94 and 95 were part of a double row of shear pins (77 through 95) spanning the northern side of the landslide that were designed to resist greater driving forces present in that area. These shear pins were 80 feet long, drilled 12 feet on center. The remainder of the shear pins installed during Phase I were 72 feet in length, generally constructed nine feet on center. During the planning phase, spacing between Shear Pins 104 through 108 had been altered in order to accommodate the subdrain outlet from the Soledad Mountain Road. However, during drilling of Shear Pin 105, the eight-inch, HDPE outlet pipe descending from Soledad Mountain Road was severed and pulled out of the ground when the spin auger was retracted from the hole. Through the use of an underground utility camera, it was found that the HDPE outlet pipe had been separated from the subdrain connection point by approximately 15 to 20 feet. In order to facilitate outlet repair, the top-of-pin elevation for Shear Pin 105 was lowered approximately five feet so that it could be reconnected at a later date during grading activities as described on page 10 of this report. Installation of Phase I shear pins was completed December 31, 2008. Slope inclinometers were installed inside Shear Pins 101 and 110 for monitoring during excavation and grading.

4.3.3 Installation of Shear Pins 77 through 84, 86 through 93 and 111 through 120 (Phase II) – Following conformation that the minimum compressive strength had been reached in Phase I CIDH shear pins, Phase II re-grading of the landslide area adjacent to Desert View Drive Alley was performed per sheet 31 of the as-built project plans (Appendix C, Volume 3) in order to facilitate the installation of the remaining CIDH shear pins. Re-grading included modifications to both the drilling and crane pads. The drill pad was extended to the north at elevation 448 feet (msl) using temporary, geogrid reinforced fill to build up the east edge of the drill pad. To the south, the contractor opted not to place temporary fills per the project plans to construct Shear Pins 115 through 120, and instead used a series of stepped pads at lower elevations (see Sheet 31 of 50, Appendix C, Volume 3). The crane pad was extended westward at an elevation of 425 feet (msl) by excavating a 0.75:1 (horizontal to vertical) cut slope below recently installed Shear Pins 94 through 110 (see Sheet 32 of 50, Appendix C, Volume 3). Temporary CIDH piers, (Sheet 41 of 50, Appendix C, Volume 3) were installed adjacent to the new cut slope to provide crane outrigger support where existing soils lacked sufficient bearing capacity. Temporary CIDH piers were demolished to a minimum depth of five feet below finished grade upon completion of shear pin installation. Installation of Phase II shear pins was completed on February 27, 2009. Slope inclinometers were installed inside Shear Pins 88, 93 and 118 for monitoring during excavation and grading.

4.3.4 Slot Cut Grading – As specified on ***Construction and Grading Plans For: Desert View Drive Alley Emergency Repair***, dated October 20, 2008, prepared by Helenschmidt Geotechnical, Inc., (Table 1), slot cut grading methods were utilized to remove recent landslide debris along Desert View Drive Alley, and construct a keyway on which to reconstruct the finished slope. At the request of the contractor, the three slots were excavated in reverse sequence compared to the order shown on the project plans. For the purposes of this discussion, the slots shall be referred to per the numbering sequence on the as-built project plans (Appendix C, Volume 3).

Excavated soils from Slot 3 were hauled off site to Fiesta Island and stored for reuse as fill in Slot 1 and during the subsequent slope restoration. Once the keyway bottom had been approved by HGI and surveyed by the City of San Diego Survey Department, fill soils derived from Slot 2 were compacted to 90% relative compaction (ASTM D-1557) using a large water-filled, sheepsfoot drum roller towed behind a Caterpillar D-6R bulldozer. Note that benches were cut as needed in the backcut during the fill process. The subdrain placement in Slot 3 was modified to reflect the higher elevation rupture surface in the backcut. Subdrains consisted of consisted of six-inch diameter, Schedule 40, perforated PVC pipe surrounded by approximately 4.5 cubic feet per lineal foot of 3/4-inch washed gravel wrapped with Mirafi 140N filter cloth. The final alignment and invert elevations are shown on the as-built plans in Appendix C (Volume 3) and on Plate 6 (Volume 4). Once the subgrade elevation in Desert View Drive Alley was reached, geogrid reinforcement consisting of Tensar BX 1200.4 was installed, starting at elevation 418.5 feet, to reconstruct the 1.5:1 (horizontal to vertical) finished slope descending from the break-in-slope point located above the recently installed shear pins west of Desert View Drive Alley. The biaxial geogrid reinforcement was rolled out parallel to the finished slope face and staked in place at the slope face to ensure that the desired embedment length was achieved. If cuts were made to accommodate curves in the finished slope, adjacent sections were overlapped by a minimum of 12 inches.

Subsequent layers of geogrid were installed every 18 inches until the finish grade elevation specified in the project plans was reached. Along the south end of the shear pin alignment, where top of pin elevations stepped up from 421 feet to 439 feet (See Table G-2, Appendix G, Volume 3), geogrid was run over the top of shear pins to increase embedment length. The fill slope in Slot 3 was terminated at approximate elevation 439 feet (msl). A north facing 0.75:1 (horizontal to vertical) false slope was left in place adjacent to Slot 2.

Excavation and fill placement in Slot 2 proceeded per the methodology used in Slot 3. Prior to the excavation of Slot 2, materials used to construct the crane pad were exported from the site.

Following excavation, the new section of subdrain was connected with the previously constructed section in Slot 3, and fill soils derived from the Slot 1 area were placed and compacted to a minimum of 90% relative compaction (ASTM D-1557). Once subgrade elevation in Desert View Drive Alley was achieved, repairs were made to the broken subdrain outlet pipe which drained the Soledad Mountain Road keyway. The eight-inch, HDPE pipe was re-exposed above Shear Pin 105 and the broken end was cut flat. The HDPE pipe was then gently reinserted into the grout lined subhorizontal boring using the arm of an excavator. Using this method, the pipe was pushed uphill approximately 15 feet before meeting resistance. The pipe was checked using a utility camera for debris, before being reconnected at the downstream end, to a six-inch PVC tightline using a rubber boot connector. The PVC tightline was then run down to the location of the future headwall on the west side of Desert View Drive Alley, while the HDPE/PVC connection point was encased in concrete to prevent future separation. Footage from the utility camera indicated that the upstream end of the HDPE tightline was within approximately three feet of the original connection point with the subdrain under Soledad Mountain Road as described on page 10 of this report. Upon completion of repairs to the subdrain, the 1.5:1 fill slope (horizontal to vertical) was constructed below the shear pins. Geogrid reinforcement was tied back into exposed geogrid in the north-facing false slope at the Slot 2-Slot 3 boundary.

Prior to excavation of Slot 1 (the final slot), forensic excavation of the fire hydrant and associated water lines displaced during landsliding was performed by plaintiff's experts and the City of San Diego, forensic consultant Ninyo and Moore, Inc. Following documentation (performed by others), the fire hydrant and water lines were removed from the site for further analysis. Slot 1 was then excavated and the subdrain was installed per the project plans. The subdrain outlet (six-inch, Schedule 40 PVC tightline) was run across to the east side of the keyway (2% fall minimum), capped and buried. Fill soils were imported from Fiesta Island in Mission Bay to fill the slot and begin slope reconstruction. Geogrid was placed in accordance with the project plans, tying into layers previously installed in Slot 2.

Note that all excavations were continuously mapped and documented by representatives of HGI. Excavations were inspected daily and relevant inclinometers were read frequently to monitor excavation stability. Limits and elevation of the keyway bottom, and the orientation and elevation of the keyway subdrain were surveyed in each slot by the City of San Diego Survey Department and are shown on Plate 6 (Appendix 4).

4.3.5 Slope Reconstruction – Once the 1.5:1 (horizontal to vertical), geogrid reinforced slope was completed and the shear pins covered with compacted fill, the toe of the 3:1 (horizontal to vertical) slope was established. From this point, re-grading and re-contouring of the existing slope face was performed between the CIDH shear pins west of Desert View Drive Alley and Soledad Mountain Road. A minimum fill spread of ten feet (horizontal) was maintained as grading operations moved upslope. Where possible, additional landslide debris was benched out and replaced with properly compacted fill soils below 5735 Soledad Mountain Road, along the original north margin of the October 3, 2007 landslide. Care was taken in this area to blend the new finished slope with the existing slope to the north. Along the south landslide margin, grades were also matched with the existing slope to the south and with the original grades along the north wall footing of 5695 Soledad Mountain Road. A mid-slope keyway was established at an approximate elevation of 450 feet (msl) (Plates 1 and 6, Volume 4), to remove a portion of an adversely oriented clay seam that was noted during slope mapping.

At approximate elevation 560 feet (msl), slope reconstruction was halted for repairs to the separated subdrain outlet below Soledad Mountain Road. A large diameter boring (six feet) was advanced, immediately east of Shear Pin 61 to a depth of approximately 30 feet. The upstream end of the eight-inch HDPE pipe (previously reinserted using and excavator bucket), and the downstream end of the six-inch, Schedule 40 PVC tightline which tied into the subdrain below Soledad Mountain Road, were then exposed by hand and reconnected using a rubber sleeve with a stainless steel clamp. The shaft was then backfilled with a two-sack slurry mix to elevation 460 feet (msl). Grading activities were then resumed, bringing fill soils up to the specified finished grades along the east side of the Soledad Mountain Road Right-of-Way. Note that Caltrans Class II aggregate base was used to complete the east side of the Soledad Mountain Road Right-of-Way, and shallow utilities were extended to the edge of the right-of-way for future connection to private utilities.

Upon completion of fill placement, minor adjustments to the 3:1 (horizontal to vertical) slope were made to provide positive drainage away from adjacent structures to the north and south of the repair area. In addition, the 1.5:1 (horizontal to vertical) slope bordering the west side of Desert View Drive Alley (below Shear Pins 77 through 120) was cut back to finished grade using a slope board. Note that all inclinometers located within the area of slope reconstruction were extended to finished grade during fill placement, and capped with either 12-inch Emco well covers or steel lock boxes.

Once finished grades were established in the slope area, an excavator was used to expose the capped subdrain outlet on the east side of Slot 1, in Desert View Drive Alley. A track-mounted drill rig (Ditch Witch JT3020 model) was then brought in to drill the outlet boring between base of Slot 1 and Desert View Drive to the east. Once completed, a six-inch, Schedule 40 PVC outlet was installed and grouted inside the boring and connected to the keyway subdrain. The downstream end was tied into a newly constructed D-25, Type A (SDRSD) curb outlet angled in the direction of surface drainage along Desert View Drive.

Fine grading of landscaped areas, irrigation installation and concrete flatwork required to restore residential properties on the east side of Desert view Drive Alley damaged during landsliding or during grading and construction, were performed by

Valley Crest, Inc., in accordance with City of San Diego requirements and plans prepared by others. This work was not inspected by HGI. Valley Crest, Inc. was also responsible for the implementation of erosion control measures.

4.3.6 Surface Drainage Improvements – Following slope restoration, permanent drainage improvements were installed per sheet 44 (Delta 3) of the As-Built project plans (Appendix C, Volume 3). The original concrete curb and gutter which prevented slope runoff between private lots along the east side of Soledad Mountain Road and Desert View Drive Alley, was replaced with a D-75 (SDRSD) brow ditch. The new brow ditch transferred water from the remaining curb and gutter behind 5735 Soledad Mountain Road to a D-7, Type F (SDRSD) catch basin located at the property boundary between 5695 and 5705 Soledad Mountain Road. From the catch basin, water was transferred downslope in a 12 inch, Schedule 40 PVC tightline to the reconstructed concrete drainage apron (installed during paving operations, as discussed below) on Desert View Drive Alley. An additional four-inch PVC tightline was also tied into the catch basin for the purpose of collecting water from roof gutters and area drains on the north side of 5695 Soledad Maintain Road. The four-inch line was capped and buried for future tie in by the property owner.

4.3.7 Paving – Repaving of the Desert View Drive Alley Right-of-Way was completed between June 12 and June 16, 2009 per the project requirements. Paving was performed in accordance with the original Desert View Drive Alley grading plans by Inter-City Engineers dated May 14, 1974, although minor changes were made to the alignment. Due to heavy construction on Desert View Drive, the Alley was repaved from Palomino Circle to the southern limit of the work area. Existing asphaltic concrete was stripped and hauled off site. The subgrade soils were scarified to a depth of 12 inches and recompacted to a minimum of 95% relative compaction (ASTM D-1557). The new pavement section consisted of three inches of asphaltic concrete over nine inches of Caltrans Class II aggregate base, compacted to a minimum of 95% relative compaction (ASTM D-1557). Drainage along Desert View Drive was restored to its original configuration so that surface runoff from the road and from the reconstructed slope above could be transferred to the existing storm drain system on Desert View Drive.

4.4 Grading and Observation and Testing

4.4.1 CIDH Shear Pin Construction – Representatives of HGI were present on a continual basis during the drilling and construction of CIDH shear pins. Borings were inspected for evidence of seepage, groundwater and caving. Reinforcement cage placement was documented to confirm that cages were set at the correct depth relative to the landslide rupture surface. Although HGI was present during concrete placement, special inspection of reinforced concrete was performed by others. Data gathered during CIDH shear pin installation and results of compressive strength test data are summarized in Appendix E (Volume 3).

Selected borings were downhole logged by a Certified Engineering Geologist, Professional Geologist or Registered Geotechnical Engineer to see that subsurface conditions conformed to those derived from earlier geotechnical investigations for design purposes. Although the primary purpose was to confirm the depth and attitude of the recent landslide failure plane, other planes of weakness, well developed joints and/or significant faults were also noted. Results of shear pin logging, combined with geologic mapping of the main excavation, were used to develop and refine the As-Built Geologic Map and cross sections (Plates 1 through 3, Volume 4).

4.4.2 Excavation – Slot cut grading within the Desert View Drive Right-of-Way was performed using conventional earthmoving equipment, including a Komatsu tracked excavator, Caterpillar D-5 and D-6 bull dozers, as well as other equipment. Excavations were constantly monitored by HGI field representatives to check conformance with the project plans (Table 1) and specifications and to monitor excavation stability. Geologic mapping and documentation was also performed daily to gather additional data on the landslide failure plane as well as other planes of weakness that may have impacted excavation activities. Plates 1, 2 and 3 (Volume 4) show the as-built geologic conditions for the site. Keyway bottoms were inspected, documented and approved prior to placement of and fill soils. As-built subdrain line and grade was also documented by HGI. As-built keyway limits and subdrain alignment and invert elevations were also surveyed by the City of San Diego when a survey crew was available.

4.4.3 Fill Placement and Compaction – HGI performed full time monitoring and testing of compacted fills and geogrid installation. Fill was tested using either the Sand Cone Method (ASTM D-1556) or the Nuclear Densometer Method (ASTM D-2922) to document a minimum of 90% relative compaction (ASTM D-1557). Fill soils compacted to less than 90% relative compaction were subjected to additional compaction effort, or scarified and recompacted until satisfactory compaction was achieved. Field density tests are summarized in Appendix F (Volume 3). Test locations are illustrated on Plate 6 (Volume 4).

Installation of Mirafi Miragrid 24XT (used for the Crane Pad), Mirafi Miragrid 10XT (temporary fills for drilling bench) and Tensar BX 1200.4 (permanent slope) was also closely monitored by representatives of HGI to check correct placement, overlap and embedment. Care was taken to make sure sheets were staked down prior to placement of fill. Creased, wrinkled or displaced sheets as a result of fill placement or equipment traffic were re-laid. Damaged or improperly cut sheets were replaced.

The upper 12 inches of subgrade soils under Desert View Drive Alley were moisture conditioned and compacted to at least 95% relative compaction (ASTM D-1557). Subgrade density test results are summarized in Appendix F (Volume 3). Asphaltic concrete was placed and compacted under direct observation and testing performed by City of San Diego inspectors, and was not part of HGI’s scope of work.

5.0 MONITORING AND INSTRUMENTATION

In order to monitor the stability temporary of open excavations and areas adjacent to the construction site, and to monitor the effects of construction equipment on surrounding structures, a construction monitoring program was implemented throughout the duration of construction activities. This program included the use of slope inclinometers, portable seismographs, crack gauges, settlement monuments and survey target reflectors. A map showing inclinometer installations and setup locations for the portable seismographs is provided as Plate 7 (Volume 4).

5.1 Slope Inclinometers

During construction, excavation stability, and stability of other adjacent slopes was monitored by a series of frequently read inclinometer installations. Inclinometer installations are shown on Plate 7 (Volume 4). Inclinometers were installed in either small diameter borings (14 total) or inside the reinforcement cages of shear pins (10 total). All installations were constructed using 2.75 OD Quick connect, non-perforated Durham-Geo/Slope Indicator (SINCO) inclinometer casing. Casings installed in small diameter borings were grouted in place by using the standard 3:1 cement/bentonite mix ratio for medium to hard soils, as specified by SINCO. Inclinometer installations were permitted by the County of San Diego, Department of Environmental Health under permit numbers LMON 105200, LMON 106088 and LMON 106332.

As illustrated on Plate 7 (Volume 4), ten installations (SP-27, SI-1, SI-2, SI-3, SI-5, SI-6, SI-9, SI-10, SI-11 and SI-14) have been destroyed. These installations were either removed during construction, or (in small diameter borings) abandoned using destruction methods approved by the County of San Diego, Department of Environmental Health.

Inclinometers were read as necessitated by construction activities. Pertinent installations close to open excavations were read daily or weekly depending on the level of construction activities, the depth of excavation and/or the level of fill placement. Installations further away from areas of construction were read less frequently. Appendix I (Volume 3) contains a table summarizing the inclinometer installations at the site, as well as data plots from every installation. Note that the inclinometer plots show representative reading dates that span the entire length of monitoring, with some interim monitoring dates omitted for clarity.

5.2 Vibration Monitoring

Two Instantel "Blastmate III" portable seismographs were set up at various locations to monitor ground vibration during construction. The purpose of the vibration monitoring was to detect vibrations specifically related to construction activity near residential properties that exceeded a threshold level. Monitoring locations included fixed setups immediately adjacent to a specific construction activity (i.e. shear pin drilling close to a residential structure or near haul routes) or portable setups. Fixed setups were secured in locked boxes to gather continuous monitoring data.

A total of 64 geophone locations were utilized (Plate 7, Volume 4). For temporary setups, the geophone was oriented directly towards the construction activity, in between the potential source of vibration (i.e. construction equipment) and the nearest residential structure. Locations were most commonly adjacent to the foundations for the residences surrounding the landslide repair, although monitoring along outlying residences was also periodically performed to monitor the effects of construction traffic to and from the site. Potential sources of construction vibration included, but was not limited to: 1) drilling of large and small diameter borings, 2) grading activities 3) CIDH shear pin construction, 4) setup, use, and breakdown of the large, mobile cranes used for placement of the steel reinforcement for shear pins, 5) assorted construction operations including heavy truck traffic, excavators, and other construction equipment utilized during the process of removal of debris, and delivery of construction materials to and from the site, 6) fill compaction, and 7) street paving.

The Instantel "Blastmate III" records several variables, including Peak Particle Velocity (PPV) and vibration frequency, which can be used to evaluate the effects of vibrations generated by construction activities on residential structures. Low frequency vibrations have been found to be capable of causing damage at low PPV. As frequency of vibration increases, the PPV level required to cause structural damage also increases. The U.S. Bureau of Mines (USBM) has recognized a "Safe Limit Criteria" for vibrations based on PPV and frequency of vibration. A PPV of 0.2 inches per second represents the lower bound of the "Safe Limit Criteria" at a frequency as low as one Hz (one cycle per second). The seismographs at this site were set at this level, recording any vibration events that exceeded 0.2 inches per second PPV.

A summary table of the vibration monitoring activity is included in Appendix H (Volume 3). Events were recorded when the threshold of 0.2 inches per were exceeded, as outlined in Appendix H (Volume 3). These generally consisted of records developed when heavy equipment, including drill rigs, bulldozers, excavators, and vibratory compaction equipment were operated in close proximity (five to ten feet) to the portable seismograph.

Note that out of the of the 370 trigger events outlined in Appendix H (Volume 3), only four, isolated events had PPV at frequencies which exceeded USBM limit criteria. In all cases, no evidence of damage to surrounding structures was observed.

5.3 Settlement and Survey Monuments

Prior to construction of the crane pad between 5720 and 5734 Desert View Drive Alley, a series of eight settlement monuments/survey points were installed around the periphery of the pad to monitor potential effects of settlement resulting from the additional loads imposed by the addition of fill. The crane pad consisted of approximately 1000 cubic yards of Caltrans Class II aggregate base reinforced with Mirafi Miragrid 24XT, compacted to 95% relative compaction (ASTM D-1557). Settlement monuments consisted of a four-foot length of galvanized steel pipe, capped on the upper end, grouted into a four-foot hole with approximately two feet of grout. Survey points adjacent to 5734 Desert View Drive Alley were scribed onto existing concrete pad at the south end of the residence. This series of eight points was monitored twice a month during shear pin installation by the City of San Diego Survey Department.

In addition, the City of San Diego Survey Department monitored a series of five fixed survey reflectors set around the periphery of 5735 Soledad Mountain Road along the north edge of the landslide, 19 survey points surrounding the landslide area and 41 survey points along Desert View Drive between residences 5613 and 5861. Data was provided to HGI monthly for review.

5.4 Post-Construction Monitoring

Several inclinometer installations remain in service as of the date of this report, as shown on Plate 7 (Appendix 4). In order to monitor the long-term performance of the landslide repair, as well as the immediate surrounding area, quarterly readings of remaining installations are anticipated to be performed for approximately one year.

6.0 GEOLOGIC CONDITIONS

6.1 Regional Geology

Regional geologic conditions in the Mount Soledad area of San Diego were discussed in detail in our ***Geotechnical Design Report for Shear Pin Landslide Stabilization of Soledad Mountain Road Right of Way, 5700 Block Soledad Mountain Road, La Jolla, California***, (Two Volumes), dated March 13, 2008, by Helenschmidt Geotechnical, Inc. Geologic conditions documented at the site during investigation and construction generally conform to published geologic maps (Kennedy, 1975, 2005) which indicate that the site is underlain by the Ardath Shale (Ta), a sedimentary unit consisting of light brown to gray, interbedded, fine grained sandstones, siltstones, and claystones.

6.2 Site Geology

Geologic mapping at the site, specifically during mapping of keyways and backcuts, revealed a number of surficial geologic units, elements from original site development during the 1960s as well as localized structural discontinuities not visible on 1:24,000 scale regional geologic maps. The following section is an overview of geologic conditions at the site, based on field mapping performed by representatives of HGI.

6.2.1 Observed Geologic Units – The geologic units described below (with the exception of the Mount Soledad Formation) are shown in plan view and cross section on Plates 1 through 3 (Volume 4), which depict the as-built geologic conditions at the site. Note that this volume of the report only discusses those units mapped or placed as fill within the limits of the Desert View Drive Alley repair. Geologic units on Plate 1 (Volume 4) are depicted in plan view as they were exposed at the maximum limits of excavation i.e. in keyway backcut slopes or benches. Descriptions of the geologic map units are as follows:

- **Artificial Fill-Older (Qaf) –** Previously placed artificial fill was encountered during preliminary investigations, and was mapped in the backcut and keyway at the south end of slot 3. This material consists of poor to moderately compacted sandy silts and clays with occasional, isolated subrounded gravel or cobbles. These fill soils were placed either during the initial rough grading of the site in the late 1950's, or during re-contouring of the 1961 landslide area, circa 1967.

- **Recent Landslide Debris (Qls_r) –** Created by landsliding on October 3, 2007, which involved a block-glide translation of a portion of a larger ancient landslide underlying the site. As observed during subsurface investigations and slot cut grading, this material generally consisted of light gray to light brown, interbedded siltstones, claystones and sandstones, derived from Ardath Shale. The materials were highly fractured. Recent landslide debris was removed with the limits of keyway excavation and grading per the requirements of project plans.

- **Colluvium (Qcol) –** Minor amounts of colluvial soils were mapped at the south end of the slot 3 excavation. The colluvium consisted of dark brown silty to sandy clay, exposed in a continuous band of variable thickness underlying the existing artificial fill (Qaf). The mapped material was moderately stiff, slightly moist, and homogenous in color, without significant roots or organic content. The colluvium represents in place, or partially reworked soil material on which fill was placed during grading of the Corona Estates development. Some portions of the colluvium were also displaced during the 1961 landslide event (Plate 4, Volume 4).

- **Ancient Landslide (Qls_a) –** As previously discussed, a larger, ancient landslide complex underlies the site, comprised of moderately fractured siltstones and claystones (derived from Ardath Shale) that are inherently unstable and have been subject to downslope movement in the geologic past. Site development has altered the surface topography, coupled with normal weathering and erosion processes prior to development, have made the limits of the ancient slide complex and difficult to discern. Interpretation of predevelopment aerial photographs and projection of bedding plane shears outside the limits of work, suggest that it underlies residential construction surrounding the landslide repair area. Within the limits of excavation, the rupture surface of the ancient landslide was approximately five to eight feet below the October 3, 2007 landslide rupture surface and continuous around most of the excavation. The rupture surface was developed on a three to six inch thick seam of remolded blue gray clay. Landslide debris between the recent rupture surface and the ancient landslide surface was relatively intact. Consequently, the rupture surface could be interpreted as a bedding plane shear in the absence of geomorphic features suggestive of the larger ancient landslide.

- **Ardath Shale (Ta) –** The bedrock unit underlying the site is mapped as the Ardath Shale. It was routinely exposed in the deeper boreholes and excavations. As observed, it consisted of poor to moderately bedded, weakly fissile, olive brown siltstone, interbedded with more massive light orange to yellow-brown siltstones and very fine grained sandstones. This material was relatively stiff and intact in contrast to the recent landslide debris. Zones of joints and minor faults were mapped within the unit, commonly trending north-northeast.

- **Mt. Soledad Formation (Tms) –** In two large diameter borings, AGLB-2 (by American Geotechnical) in Soledad Mountain Road and LD-4 on lower Desert View Drive, sharp contacts between the Ardath Shale and an underlying conglomerate from the Mt. Soledad Formation were encountered at approximate elevations of 382 feet (msl) and 298 feet (msl), respectively. The conglomerate portion of the Mt. Soledad Formation is generally a clast supported conglomerate (60% clasts, 40% matrix). Clasts were well rounded, one to eight inches in diameter and appeared not to be imbricated where exposed in the borings.

6.2.2 <u>Excavation Conditions</u> – Excavation conditions were continuously documented by representatives of HGI. Keyway and backcut conditions are presented in Plates 1 and 4 (Volume 4) respectively. Selected photographs showing excavations conditions are presented on Plate 4 (Volume 4) as well as in Figures 2A-2C and 3A-3M.

In general, the limits of excavation and keyway configuration were in accordance with the project plans. Minor modifications to the limits of excavation on the north and south ends of the keyway were made as a result of variations in the geometry of the slide plane. The keyway was founded in competent Ardath Shale, a minimum of two feet below the landslide rupture surface on the west side of the keyway. Soils related to the 1961 landslide event were exposed at the south end of the excavation, while fill soils related to the extension of Desert View Drive Alley to the south in 1967 were documented on the east side of the keyway.

6.2.3 Geologic Structure – As discussed in Volume 1, two, essentially parallel sheared clay seams, five to eight feet apart underlying the October 3, 2007 landslide, were documented throughout the project, both in several large diameter borings, as well as in repair excavations within Soledad Mountain Road and Desert View Drive Right-of-Ways. These shear zones were usually between one and three inches thick, although thicknesses up to six inches were noted, especially where locally thickened by movement along a discontinuity such as micro faults, conjugate joint sets, etc. Typically these shear zones consist of blue-gray to black, sheared clay. Note that sheared clay seams are not only generated by landsliding, but also by flexural slip folding related to regional or local tectonic forces. When sedimentary units are folded or tilted by tectonic forces, softer beds (such as clay seams) will deform plastically resulting in internal shearing, whereas harder, more lithified beds will deform in a brittle manner through fracturing, faulting, etc. The sheared clay seam on which the October 3, 2007 landslide failed was highly sheared, soft and plastic with numerous, well developed polished parting surfaces. Slickensides were usually present, although they were often oriented east-southeast, rather than east-northeast which was the resultant direction of movement for the landslide mass. Localized brecciation in the upper six to twelve inches immediately above the shear surface was also common, sometimes occurring below the slide plane as well. Plate 5 (Volume 4) depicts the structure contour map of the surface along which the October 3, 2007 landslide failed. Through close examination of the materials above and below the slide plane, it is evident that the recent landslide mobilized along a “compound” shear plane. During the repair of Soledad Mountain Road, it was evident the south and central portions of the landslide mobilized along the upper of the two sub-parallel sheared clay seams. However, on the north side of the landslide, the two sheared clay seams are disrupted, presumably truncated by faulting/shearing along a high angle plane(s) (See AB1–1' and AB4–4', Plates 2 and 3, Volume 4), with only one sheared clay seam apparent on the north side of the landslide. The backcut along Desert View Drive Alley presented similar geologic exposure, with the failure plane of the recent slide stepping down from the upper sheared clay seam to the lower sheared clay seam east of Shear Pin 96.

The reason for the apparent "merger" of the two sub-parallel clay seams, as outlined above is not well understood. As has been well documented in the Ardath Shale, bedding is often laterally discontinuous, indicative of changing shallow marine conditions that result in lateral variations in grain size. Changes in depositional conditions, such as energy, sediment supply and sedimentation rate are the main controls on bed thickness, and often cause lateral variations in thickness of sedimentary bedding, or beds to die out altogether. Although original depositional environment explains much of the variation in bedding noted at the site, which often made stratigraphic correlations between borings difficult, it does not appear to explain the change in slide plane geometry on the north side of the slide. It is our opinion, based upon field mapping and downhole logging of borings beyond the northern limits of the October 3, 2007 landslide, that a northeast trending "fault zone" exists, comprised of multiple steep, southeast dipping parallel to sub-parallel sheared planes. This broad discontinuity is on the order of 20 to 40 feet wide in plan view, and is believed to be the probable cause of the highly sheared, disrupted geologic exposures logged in borings beyond the northern margin of the landslide. This shear zone may have limited the northern expansion of the October 3, 2007 landslide. Exposure in the north end of the keyway in Desert View Drive Alley also suggests that this zone may represent a scarp within the body of the ancient landslide, which once failed in a southeasterly direction relative to the recent landslide. Supporting evidence for this theory is seen in the down-dropped portion of slide debris (mapped as Qls_a) immediately to the north and below the recent landslide mass, which is lower in elevation than materials mapped as Qls_a to the north of the mapped limits of the October 3, 2007 landslide (Plates 1 and 4, Volume 4).

Plate 5 (Volume 4) shows the structure contour map for the landslide rupture surface of the October 3, 2007 landslide. It was constructed using attitudes recorded during downhole logging of large diameter and shear pin borings, as well as from exposures formed during keyway excavations. The surface is generally synclinal in shape, with an east-northeast plunging fold axis. In addition, borings logged north of the landslide in Soledad Mountain Road, such as LD-2, AGLB-2, SP-34 and SP-44 contained abundant high angle shears with offsets up to several feet across them, which in addition to a lack of data to the north of the recent landslide mass, make it very difficult to contour the lower sheared clay seam accurately.

6.3 Groundwater

The permanent groundwater table underlying Soledad Mountain is well below ground surface elevations at the site. In their geotechnical investigation of landsliding at lower Desert View Drive (1991), Leighton and Associates, Inc. indicated that no groundwater was encountered to their maximum depth explored of 181 feet. No groundwater table or significant perched water conditions were encountered within the recent landslide during the drilling performed for the investigation or repair, indicating that the groundwater table in the area of the recent landslide is likely more than 200 feet below the existing ground surface. Minor seepage was observed in the upper portion of Shear Pin 120 south of the landslide toe.

6.4 Seismicity

The project site is located within a seismically active area (UBC Seismic Zone 4) and within the Rose Canyon Fault Zone. Historically, this area has been subjected to strong seismic ground shaking from major earthquakes, and it will continue to experience strong ground shaking in the future. An active fault is defined as fault that has experienced Holocene displacement (movement within the last 11,000 years). According to regional geologic literature, the closest known active fault is the northwest-southeast trending Mt. Soledad strand of the Rose Canyon Fault Zone, located approximately 300-500 feet northwest of the site. Several other active faults and numerous potentially-active and pre-Quaternary faults also are present within the vicinity. Figure 4 illustrates the proximity of the site to the Rose Canyon Fault Zone, a series of faults and associate folds aligned parallel to the drainage northeast of the site. The California Geological Survey has mapped the limit of the Alquist Priolo Zone below Lower Desert View Drive, approximately 350 feet northeast of the site. High angle shears and disrupted bedding were observed within the bedrock materials within the repair area, although no evidence of active faulting was apparent in exposures observed within the site excavation.

7.0 AS-BUILT STABILITY ANALYSES

Our stability analysis was performed utilizing the XSTABL computer program. XSTABL is a version of the STABL computer program developed at Purdue University. The analyses included consideration of failure along the well developed sheared clay seam that defines the basal rupture surface of the active landslide and a slightly deeper shear surface which is either an ancient bedding plane shear or the basal rupture surface of a portion of the ancient landslide that did not experience movement in 2007. We have updated our geologic model for the area based on detailed mapping performed during grading. We have also updated the critical cross sections through the site (Plates 5-6, Volume 4) with the as-built profiles. Required shear pin loads were determined based on the current "as-built" geologic and soil conditions and assuming a future 1.5:1 (horizontal to vertical) slope extending from the shear pins up to a level pad at the approximate elevation of Soledad Mountain Road. These forces were compared with the design shear pin forces incorporated into the plans. In each case, the design shear pin resistance was found to be adequate (factor of safety of at least 1.5).

A second analysis was performed on representative cross sections to check for a potential failure over the top of the shear pins with an assumed future 1.5:1 (horizontal to vertical) slope extending from the shear pins up to a level pad at the approximate elevation of Soledad Mountain Road. Final factors of safety were calculated using a Spencer’s analysis which satisfies all conditions of equilibrium. Each of the analyses indicated a minimum factor of safety of 1.5 for a potential failure over the shear pins. Plots of the stability analyses and a summary table of results are included in Appendix I.

8.0 CONCLUSIONS

The results of our field observations and testing during the repair of the Desert View Drive Alley Right-of-Way indicate that the repair including CIDH shear pins, subdrainage and engineered fill has been constructed in accordance with the recommendations of the project geotechnical report and plans. Variations from the approved project plans were included in three delta plan changes, Sheets 21 and 24 (original construction plan numbering), and field changes due to actual conditions encountered during grading and construction. All field changes have been incorporated into the final, as-built plans (Appendix C, Volume 3).

Special inspection was performed throughout the repair in accordance with the requirements of the approved project plans. Special inspection results, summarized in Appendix E (Volume 3), indicate that all reinforced concrete for CIDH shear pins meets or exceeds the project specifications.

Results of construction monitoring construction induced vibrations produced by heavy equipment operation were generally within tolerable limits for residential structures adjacent to the repair.

Geologic and geotechnical conditions encountered during construction were generally as described in the project geotechnical report dated March 13, 2008 with some modifications to the October 3, 2007 rupture surface and the underlying ancient landslide rupture surface in the toe area of the landslide. Refinements to the geologic model are presented herein. No unusual geologic or geotechnical conditions were encountered during grading and construction that would adversely affect the performance of recently constructed improvements.

9.0 RECOMMENDATIONS

The following recommendations are provided by HGI with respect to the completed repair of the Desert View Drive Alley Right-of-Way and adjacent private residences:

- **Slope Maintenance** – Property owners whose land is on or adjacent to the now repaired October 3, 2007 landslide should be responsible for all slope maintenance on their respective properties. Slope areas on or bordering repair area should be periodically checked for erosion, areas of concentrated runoff, broken irrigation lines and other features that may affect the performance of the repair. Erosion gullies or areas of concentrated runoff should be repaired by redirecting drainage and/or by re-contouring. Any significant disturbance to the slopes or broken water lines should be repaired immediately. Inspections should be performed at least annually and following significant rainfall episodes.

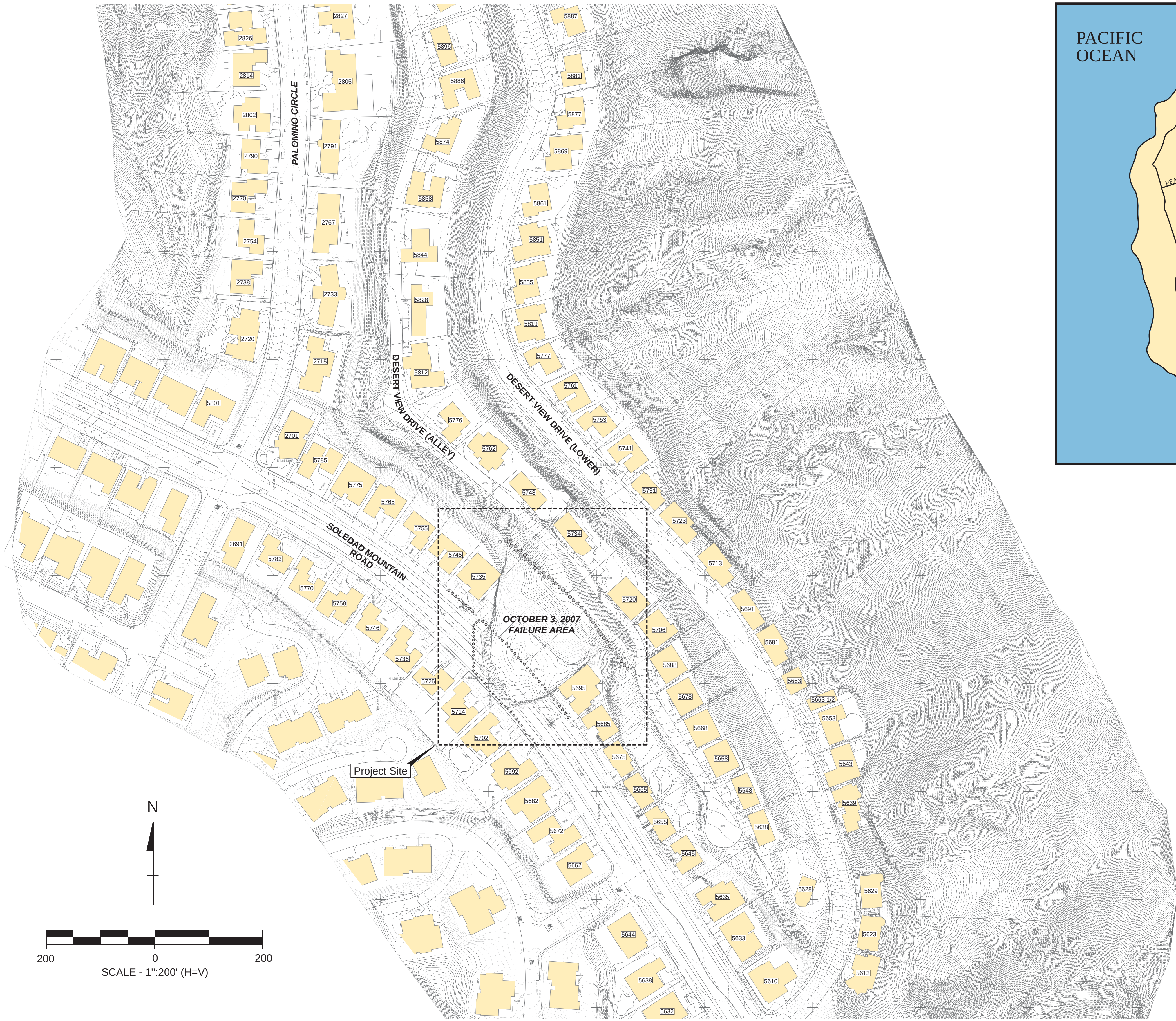
- **Drainage Maintenance** – The subject repair included restoration of surface water drainage catchments on the Soledad Mountain Road properties. This included an area drain pipe along the northwestern side yard of 5695, and a catch basin along the property line between 5695 and 5703, providing top-of-slope drainage for the Soledad Mountain Road properties similar to the pre-slide condition. Responsibility of maintenance of these drainage facilities lies with the respective property owners.

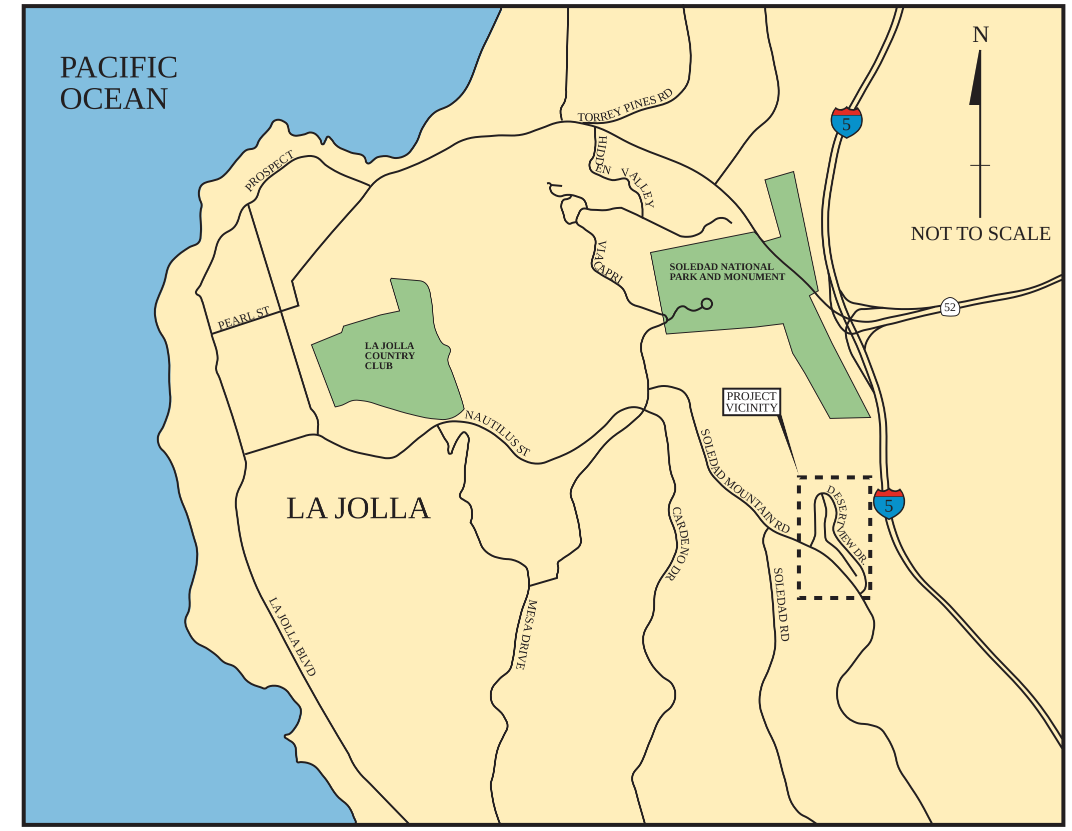
- **Inclinometers** – Continued inclinometer monitoring is recommended for the installations at the site. Long term monitoring of all serviceable inclinometers is recommended twice a year and following periods of heavy rainfall.

- **Re-development of Properties Affected by Landsliding** – The subject repair included restoration of site grades on the private properties directly impacted by the October 3, 2007 landslide: 5695, 5703, 5715, 5725, and 5735 Soledad Mountain Road as well as 5734 Desert View Drive. Our scope of work was not directed at stabilization of private properties for future development. Site-specific geotechnical investigations of these properties should be performed independently of the conclusions and results of the Soledad Mountain Road and Desert View Drive Alley stabilization activities presented herein. HGI assumes no responsibility for the use of geologic or geotechnical data developed during this project and used by others in conjunction with any private development or property use. Review and approval of future private property development is within the purview of the City of San Diego.

10.0 LIMITATIONS

Our services consist of professional opinions and recommendations made in accordance with generally accepted engineering geology and geotechnical engineering principles and practices. No warranty, express or implied, or merchantability of fitness, is made or intended in connection with our work, by the proposal for consulting or other services, or by the furnishing of oral or written reports or findings.



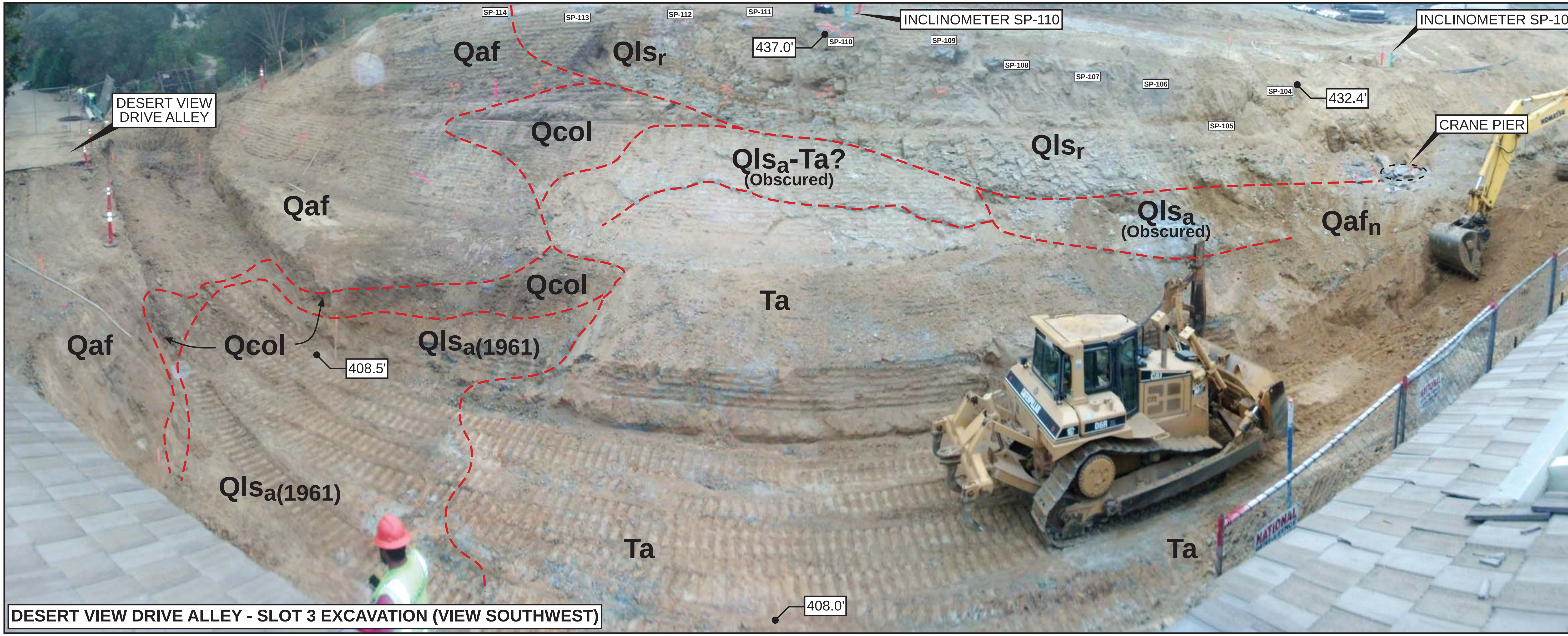


Helenschmidt Geotechnical, Inc.

Site Location Map

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: 1 Inch : 200 Feet	Figure Number: 1



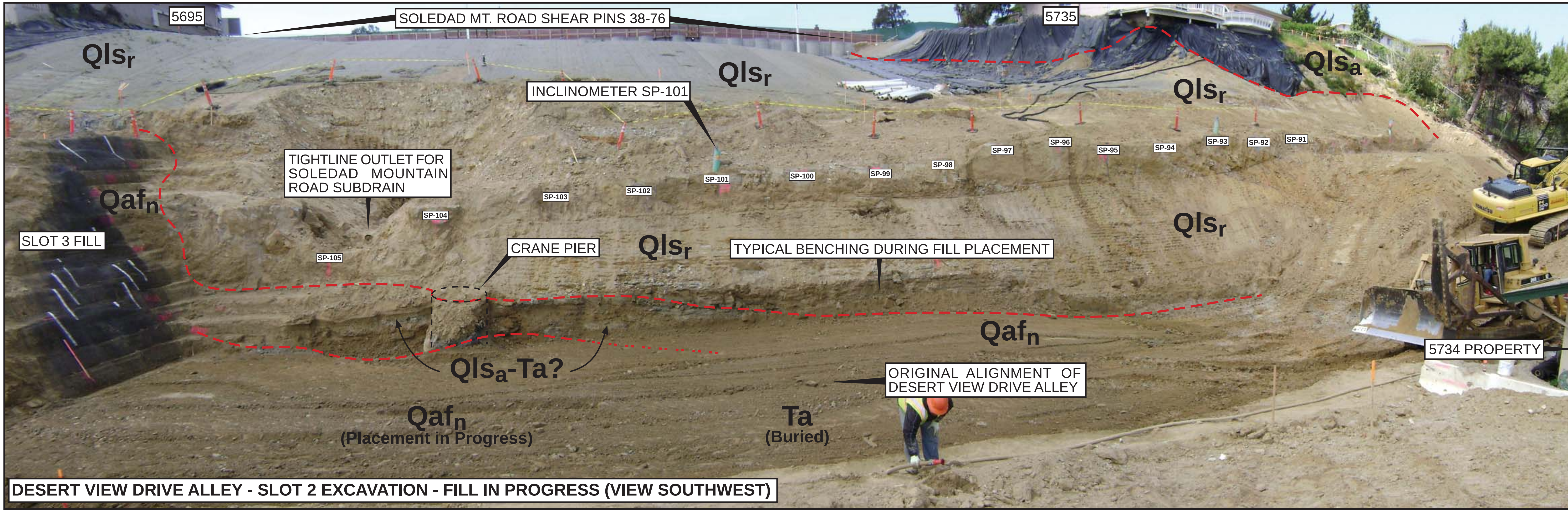
DESERT VIEW DRIVE ALLEY - SLOT 3 EXCAVATION (VIEW SOUTHWEST)

Helenschmidt Geotechnical, Inc.

Annotated Excavation Photographs

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 2A

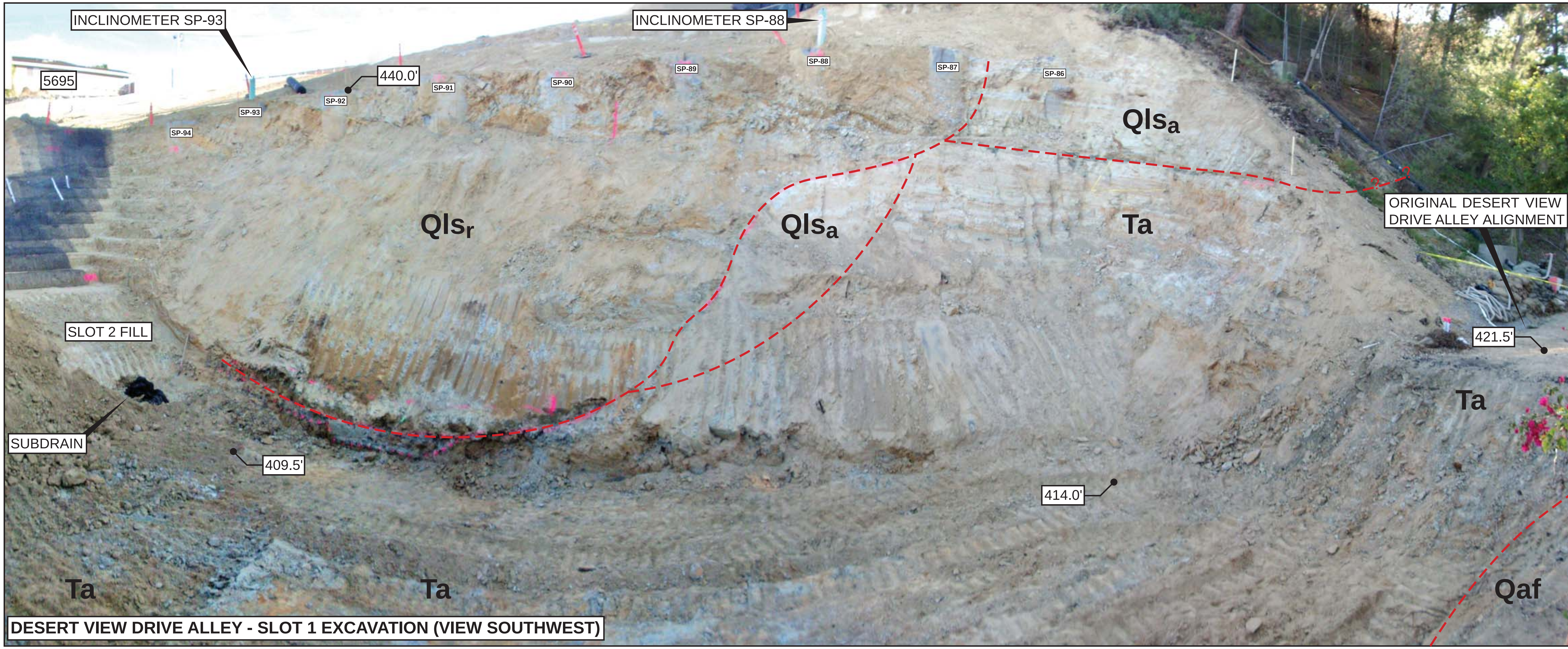


Helenschmidt Geotechnical, Inc.

Annotated Excavation Photographs

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 2B



Helenschmidt Geotechnical, Inc.

Annotated Excavation Photographs

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 2C

INSTALLATION OF GEOGRID DURING CONSTRUCTION OF CRANE PAD

CONSTRUCTION OF 24-INCH THICK MAT FOUNDATION FOR CRANE OUTRIGGER SUPPORT

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3A

SHEAR PIN DRILLING ON TEMPORARY DRILLING BENCH AT ELEVATION 440'

DRILLING AND HEAVY LIFTING EQUIPMENT SETUP DURING SHEAR PIN INSTALLATION

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3B

PUMPING CONCRETE FOR CIDH SHEAR PIN VIA BOOM TRUCK ON SOLEDAD MOUNTAIN ROAD

CONCRETE PLACEMENT INSIDE REINFORCEMENT CAGE VIA TREMIE METHOD

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3C

LIFTING OF REINFORCEMENT CAGE

RIGGING SETUP FOR LIFTING OF REINFORCEMENT CAGE

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3D

VIBRATION MONITORING DURING DRILLING OPERATIONS

INCLINOMETER MONITORING DUING EXCAVATION OF SLOT 3

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3E

SLOT 3 BACKCUT

GEOGRID PLACEMENT AT ELEVATION 427.5' DURING CONSTRUCTION OF 1.5:1 (H : V) SLOPE ABOVE SLOT 3

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3F

PLACEMENT OF FILL ON TOP OF GEOGRID LAYER

SUBDRAIN CONSTRUCTION AT THE BOTTOM OF SLOT 2

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3G

EXCAVATION ACTIVITIES IN SLOT 2

SPREADING OF FILL LIFT IN SLOT 2

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3H

SOUTH END OF SLOT 2 KEYWAY

FILL COMPACTION IN SLOT 2 USING SHEEPSFOOT ROLLER PULLED BEHIND A CATERPILLAR D-6R

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3I

TIGHTLINE CONNECTION FOR SOLEDAD MOUNTAIN ROAD SUBDRAIN OUTLET

GEOGRID PLACEMENT IN SLOT 2

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3J

NORTHERN MARGIN OF RECENT LANDSLIDE EXPOSED IN SLOT 1

DRILLING OF OUTLET FOR DESERT VIEW DRIVE ALLEY KEYWAY SUBDRAIN

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3K

FINISH GRADING OF 1.5:1 (H : V) SLOPE ABOVE DESERT VIEW DRIVE ALLEY

TRENCH EXCAVATION AT SOUTH END OF FINISHED SLOPE FOR 12-INCH, SCH. 40 PVC TIGHTLINE WHICH CONVEYS SURFACE RUNOFF INTERCEPTED BY BROW DITCH TO DESERT VIEW DRIVE ALLEY

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3L

RIGID PAVEMENT DRAINAGE SWALE AT SOUTH END OF DESERT VIEW DRIVE ALLEY

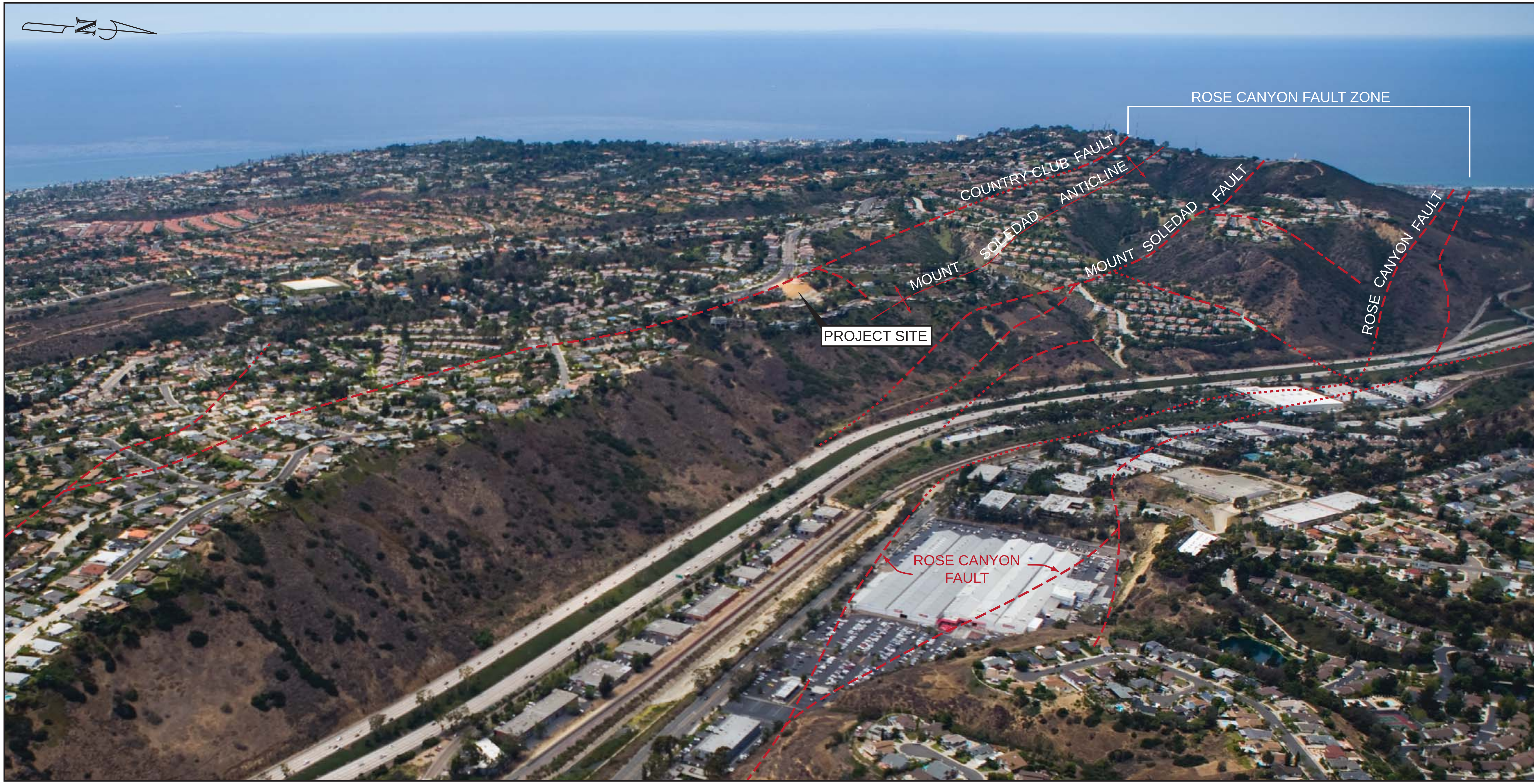
SUBGRADE COMPACTION DURING REPAVING OF DESERT VIEW DRIVE ALLEY

Helenschmidt Geotechnical, Inc.

Construction Photos

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 3M



APPROXIMATELY LOCATED FAULT DOTTED WHERE CONCEALED

APPROXIMATE AXIS OF SOLEDAD MOUNTAIN ROAD ANTICLINE

*(ADAPTED FROM KENNEDY, CGS BULLETIN 200)

Helenschmidt Geotechnical, Inc.

Approximate Location of Rose Canyon Fault Zone

Soledad Mountain Road Landslide
La Jolla, California

Project Number: 107069	Date: October 2010
Drafted: VN	Eng/Geo: SRH/RSA/MH
Scale: Not to Scale	Figure Number: 4